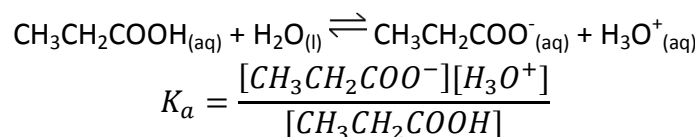


## Question One

The  $K_a$  for propanoic acid is  $1.35 \times 10^{-5} \text{ mol L}^{-1}$  at  $25^\circ\text{C}$

- (a) Write the  $K_a$  expression for the dissociation of propanoic acid,  $\text{CH}_3\text{CH}_2\text{COOH}$ .



- (b) Calculate the pH of a  $0.120 \text{ mol L}^{-1}$  solution of propanoic acid at  $25^\circ\text{C}$ . Include any assumptions you may make.

Assumptions are...

Most of the  $\text{CH}_3\text{CH}_2\text{COOH}_{(\text{aq})}$  does not dissociate as the  $K_a$  is small.  $[\text{CH}_3\text{CH}_2\text{COOH}] = 0.120 \text{ mol L}^{-1}$

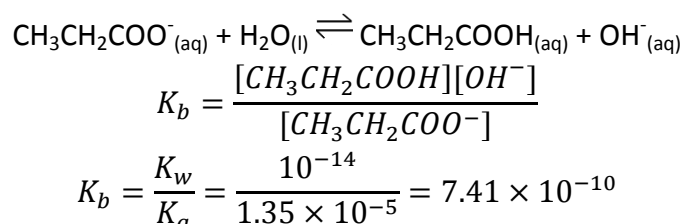
Also  $[\text{CH}_3\text{CH}_2\text{COO}^-] = [\text{H}_3\text{O}^+]$  because  $\text{H}_3\text{O}^+$  from water dissociation is significantly small

$$K_a = \frac{[\text{H}_3\text{O}^+]^2}{c\text{CH}_3\text{CH}_2\text{COOH}} = \frac{[\text{H}_3\text{O}^+]^2}{0.120} = 1.35 \times 10^{-5}$$

$$[\text{H}_3\text{O}^+] = \sqrt{(1.35 \times 10^{-5} \times 0.120)} = 0.001273 \text{ mol L}^{-1}$$

$$\text{pH} = -\log(0.001273) = \underline{2.90}$$

- (c) Calculate the pH of a  $0.120 \text{ mol L}^{-1}$  solution of sodium propanoate at  $25^\circ\text{C}$ . Include any assumption you may make.



Assumptions are...

Most of the  $\text{CH}_3\text{CH}_2\text{COO}^-$  does not dissociate as  $K_b$  is small.  $[\text{CH}_3\text{CH}_2\text{COO}^-] = 0.120 \text{ mol L}^{-1}$

Also  $[\text{CH}_3\text{COOH}] = [\text{OH}^-]$  because  $[\text{OH}^-]$  from water dissociation is significantly small

$$K_b = \frac{[\text{OH}^-]^2}{c\text{CH}_3\text{CH}_2\text{COO}^-} = \frac{[\text{OH}^-]^2}{0.120} = 7.41 \times 10^{-10}$$

$$[\text{OH}^-] = \sqrt{(7.41 \times 10^{-10} \times 0.120)} = 9.43 \times 10^{-6} \text{ mol L}^{-1}$$

$$[\text{H}_3\text{O}^+] = \frac{K_w}{[\text{OH}^-]} = \frac{10^{-14}}{9.43 \times 10^{-6}} = 1.06 \times 10^{-9} \text{ mol L}^{-1}$$

$$\text{pH} = -\log(1.06 \times 10^{-9}) = \underline{8.97}$$

- (d) What is the concentration of propanoic acid in the solution that gives a pH of 4.5

$$K_a = \frac{[\text{H}_3\text{O}^+]^2}{c\text{CH}_3\text{CH}_2\text{COOH}}$$

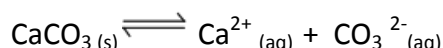
$$[\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-4.5} = 3.16 \times 10^{-5} \text{ mol L}^{-1}$$

$$1.35 \times 10^{-5} = \frac{[3.16 \times 10^{-5}]^2}{c\text{CH}_3\text{CH}_2\text{COOH}}$$

$$c\text{CH}_3\text{CH}_2\text{COOH} = \frac{[3.16 \times 10^{-5}]^2}{1.35 \times 10^{-5}} = 7.41 \times 10^{-5} \text{ mol L}^{-1}$$

## Question Two

Shellfish build shells mainly of calcium carbonate, which is only slightly soluble in water.



- (a) Write the  $K_s$  expression for  $\text{CaCO}_3$

$$K_s = [\text{Ca}^{2+}][\text{CO}_3^{2-}]$$

- (b)  $K_s$  for  $\text{CaCO}_3$  at  $25^\circ\text{C}$  is  $5.0 \times 10^{-9}$ . Calculate the solubility of  $\text{CaCO}_3$  in pure water.

$\text{CaCO}_3$  is an AB type salt

$$\text{Solubility} = \sqrt{K_s} = \sqrt{5.0 \times 10^{-9}} = 7.07 \times 10^{-5} \text{ molL}^{-1}$$

- (c) What would be the solubility of  $\text{CaCO}_3$  in  $0.1 \text{ molL}^{-1}$  of  $\text{Na}_2\text{CO}_3$

$$K_s = [\text{Ca}^{2+}][\text{CO}_3^{2-}]$$

$$5.0 \times 10^{-9} = [\text{Ca}^{2+}] \times 0.1$$

$$[\text{Ca}^{2+}] = \text{solubility} = \frac{5.0 \times 10^{-9}}{0.1} = 5 \times 10^{-8} \text{ molL}^{-1}$$

- (d) Discuss with equations and calculations if a precipitate of  $\text{CaCO}_3$  will form when 85 mL of sea water with  $\text{Ca}^{2+}$  concentration of  $0.0260 \text{ molL}^{-1}$  is mixed with 900 mL of  $\text{Na}_2\text{CO}_3$  solution with a concentration of  $0.020 \text{ molL}^{-1}$

$$\text{Amount of Ca}^{2+} = 0.026 \text{ molL}^{-1} \times 0.085 \text{ L} = 0.00221 \text{ mol}$$

$$\text{Amount of CO}_3^{2-} = 0.02 \text{ molL}^{-1} \times 0.9 \text{ L} = 0.018 \text{ mol}$$

$$[\text{Ca}^{2+}] = 0.00221 \text{ mol} \div (0.085 + 0.9) \text{ L} = 0.002244 \text{ molL}^{-1}$$

$$[\text{CO}_3^{2-}] = 0.018 \text{ mol} \div (0.085 + 0.9) \text{ L} = 0.018274 \text{ molL}^{-1}$$

$$\text{IP} = [\text{Ca}^{2+}][\text{CO}_3^{2-}] = 0.002244 \text{ molL}^{-1} \times 0.018274 \text{ molL}^{-1} = 4.1 \times 10^{-5}$$

$\text{IP} > K_s$  therefore the mixture is over saturated, precipitate will form.